

Assignment 1 (EE620) (23-01-2019)

Values for reference:

$T_{ox} = 5 \text{ nm}$

$N_A = 10^{17} / \text{cm}^3$

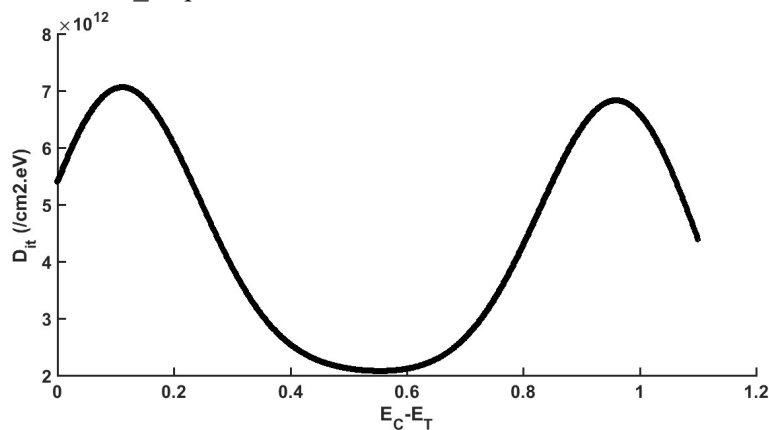
Fermi level of gate is at the conduction band of n+ type Si.

(Note: If any data is missing then assume an appropriate value and clearly mention your assumption)

1. Obtain a plot for total substrate charge, $|Q|$ versus potential at oxide/semiconductor interface (band bending ψ_s), for an MOS capacitor. [5 M]

$$Q = -\epsilon_{si} \left(-\frac{d\psi_s}{dx} \right) = \pm \sqrt{2\epsilon_{si} kT N_A} \left[(e^{-q\psi_s/kT} + \frac{q\psi_s}{kT} - 1) + \frac{n_i^2}{N_A^2} (e^{q\psi_s/kT} - \frac{q\psi_s}{kT} - 1) \right]^{1/2}$$

2. Obtain a plot for potential at oxide/semiconductor interface (i.e. band bending ψ_s) versus gate bias (V_G) for an MOS capacitor. [5 M]
3. Obtain LFCV (low frequency C-V) and HFCV (High frequency C-V) curves using the equation for Q. Do the derivative manually and then compare with the numerical derivation. [10 M]
4. Vary oxide thickness ($T_{ox}=3, 5, 7\text{nm}$ for $N_A=1e17$) and doping ($N_A=1e14, 1e16$ & $1e18 / \text{cc}$ for $T_{ox}=5\text{nm}$) and see the variations in C-V. Try to explain your observations. [10 M]
5. Do the above calculations (Q1 to Q4) using depletion approximation and show the comparative plots. [10 M]
6. Assume a fixed uniform oxide charge density $\rho(x)=1e18/\text{cc}$ throughout the oxide. Show the shift in the C-V curves. [5 M]
7. An interface trap profile is shown in the figure below. Using a similar D_{it} profile and assuming the charge neutrality point to be located at mid gap, calculate G_p and C_p for the frequencies (1e3, 1e4, 1e5, 1e6) Hz. To calculate τ use $n_i=1.5e10$, $v_{th}=2.6e7$, $\sigma=1e-15$. From this, calculate C_M and G_M . Plot V_g vs $C_M(\omega)$ (Both **LFCV** and **HFCV**). (Note : You should obtain a stretch in C-V). (Meaning of the terms and required equations can be found in the lecture slide 'Set_04.pdf').



Equation for D_{it} is given blow

$$\sum_{i=1}^3 A_i \exp\left(-\left(\frac{E_{it} - B_i}{C_i}\right)^2\right)$$

where; $A_1=A_2=6e12, A_3=2e12$; $B_1=0.1, B_2=0.97, B_3=0.5$; $C_1=C_2=0.2, C_3=0.5$. (You can have your own similar ‘U’ shaped D_{it}). [15 M]